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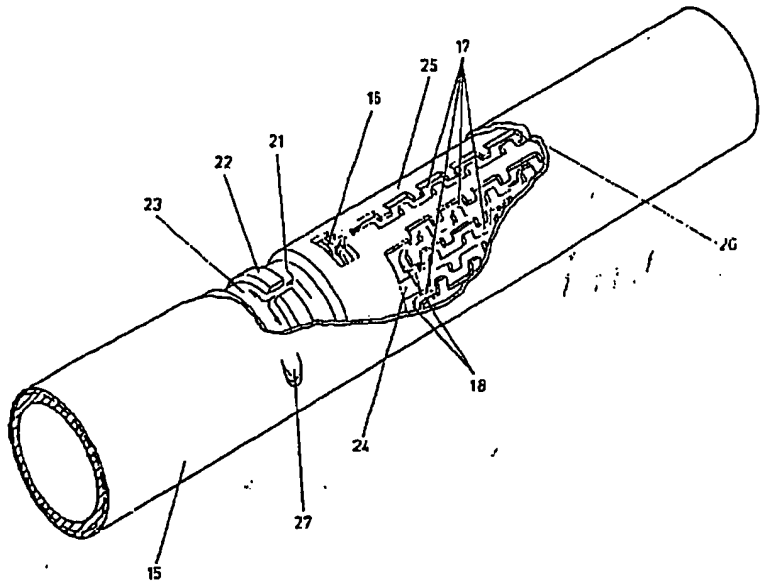
(54) Title: DRIP IRRIGATION TUBE AND METHOD OF MANUFACTURING SAME



(57) Abstract

The invention relates to a plastic drip irrigation tube and a method of manufacturing such a tube. The tube (15) is formed from an extruded inner part (25) which has impressed into its outer surface a series of long tortuous channels (17) which extend generally longitudinally of the tube (15). An outer part (26) is then extruded over and is coextensive with the inner part (25) to form an essentially integral drip irrigation tube (15). The tortuous channels (17) are arranged to provide a significant pressure reduction between an inlet (16) and an outlet (27). The tortuous channels (17) are impressed into the outer surface of the inner part (25) by a number of segment dies radially arranged around the inner part (25) with an internal mandrel providing support and reaction for the segment dies during the impressing operation.

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DRIP IRRIGATION TUBE AND METHOD OF MANUFACTURING SAME

This invention relates to drip irrigation tube and to a method of manufacture of such tube.

One of the problems to which this invention is directed relates to providing at the cheapest possible cost, a distributed water outlet system in which water delivered into a first principal tube at a delivery pressure is allowed to drip from a number of distributed outlets at significantly reduced pressures.

Many people have previously attempted to achieve this but have hitherto encountered significant technical and economic problems.

For instance, Gilaad (U.S.A. Patent No. 3792588) has proposed a separately manufactured pressure reduction device that is to be connected at spaced apart intervals with hose.

The problem with such an arrangement is that there is very substantive cost in firstly manufacturing as a discrete component such a pressure reduction device and the costs associated with connecting this with spaced apart pipe make the overall costs prohibitive.

In Drossbach (Australian Patent No. 511876) there is disclosed two co-axial tubes in which there is a channel formed within an outer surface of the inner tube and which follows a spiral path around the axis of the inner tube.

Further, the spiral path follows a direction so that pressure reduction is achieved substantially by laminar flow losses.

In order to provide substantial pressure reduction, the length of a channel between inlet and outlet has to be substantial in practice or the cross sectional area of the channel has to be very small.

If the cross sectional area of the channel is very small, the channel becomes prone to blockage by particles that can be found or formed from suspended colloidal material in irrigation waters.

It is therefore necessary in order to provide adequate pressure reduction without being vulnerable to such blockage, to provide that there are substantial lengths of channel available for control of water from any inlet to an outlet.

In order to provide for adequate channel length in many circumstances, it then becomes necessary to enlarge the diameter of the tube for this purpose only and there is therefore a substantial cost penalty in having to provide such larger tube which might otherwise be unnecessary for application.

Further however, it becomes very difficult to control the location of these outlets might be required close to one another in certain applications.

There simply may not be sufficient length of spiral channel to provide adequate pressure reduction for each of the close outlets.

One of the advantages of the Drossbach principal however is that by providing a separately formed outlet tube which is continuous along the length of the inner tube, there is therefore provided a strengthening of the tube along its full length so that the thickness of material necessary for any selected pressure for the inner tube can be appropriately reduced, hence further providing a cost reduction.

The problem therefore is to propose an arrangement which can both keep the cost of such materials to a minimum while providing improved pressure reduction capability with an aperture channel which will not be prone to blockage and whereby substantial flexibility in the location of outlets can be achieved.

According to this invention this is achieved by providing that there is a drip irrigation tube arrangement of plastics material where the tube is comprised of an inner part and an outer part, in which the outer part entirely surrounds the inner part and in which the inner part and the outer part are of substantially the same length, the arrangement being characterised in that there is formed so as to extend into an outer surface of the inner part, a plurality of channel shapes which are closed over by the outer part to form thereby pressure reduction conduits providing a tortuous pathway for liquid between for each pressure reduction conduit an inlet from within the tube to

each respective pressure reduction conduit and an outlet between each respective pressure reduction conduit and an outer side of the said outer part.

This then is distinguished from the arrangement in which the channel direction is continuously spiral around the substantial diameter of the tube.

There is, in preference, provided a pathway direction which is tortuous by providing for a plurality of substantial changes of flow direction of substantially 90° or more between an inlet and an outlet which can thereby provide a substantial pressure loss by reason of kinetic energy losses.

Each channel shape is provided by at least one long part which has a predominant direction extending substantially parallel to a center axis of the tube.

Preferably each tortuous channel is formed as at least two long parts each of which has a predominant direction extending substantially parallel to a center axis of the tube and each being located adjacent each other around the outer surface of the inner part.

Preferably, each of the long parts is connected at one end to a channel commonly connecting other of the long parts to either an inlet os an outlet aperture.

Conventionally, the inlet would extend from within the tube through the inner part to a first end of one of the passage ways and the outlet would extend from an end of the passage ways through an outer part.

Reference is made to an inner part and to an outer part and these are distinguished by references to an outer surface of the inner part and so on.

The terminology "an inner part" and "an outer part" is intended to embrace two types of constructions, one in which there are two tubes, one around the other, the outer tube tightly fitting but not welded to or substantially integral with the inner tube. The second arrangement however is the case where the outer part is either welded or glued or is otherwise affixed to the inner part so that it becomes either difficult or perhaps impossible to distinguish the two

parts from an integral article, where however they have been separately formed and indeed could comprise plastics materials which can be differently formulated and indeed can provide differing polymer orientation so that there can indeed be a strengthening effect between the two parts.

Such an arrangement can be achieved for instance where a first inner tube is passed through a coextrusion or second die and there is an outer tube extruded directly around the inner tube while both are in a sufficient melt state to cause substantial adhesion or integration.

It has to be emphasized that one of the more significant problems in relation to proposing such an arrangement is to establish that it is possible to manufacture in a continuing and economic manner such an arrangement.

It is presumed that the material must be able to be made in an ongoing in line situation where the material is directly exiting from an extrusion die and is able to be treated in such a way as to have these channels formed therein on this ongoing basis in such a way that the outlet and aperture spacing can be selected from time to time and accordingly varied and furthermore, that the extent of pressure reduction achieved can also be selected relatively readily on an ongoing basis from time to time.

This is in fact achieved by providing that the tortuous channel has a predominant direction along which it will direct the water and that there is accordingly located a plurality of such long parts which are located substantially parallel to an axis of the tube into which the shape is impressed and which are located adjacent each other around the circumference of the outer surface of the inner part.

By arranging the main channel parts in this way, these can be interconnected both at one end or another or even at intermediate parts between their ends so that by having a changeable die part which can either impress a bridging channel between the main channels or not will effectively change the pressure reduction length.

According to a further form of this invention there is proposed a method of manufacture of a drip irrigation tube which comprises the steps of extruding as an inner part a first tube, impressing into an outer surface of such inner

part at spaced apart locations along the said first tube a plurality of channel shapes providing for a tortuous pathway, and then closing over the said inner part including such channel shapes with an outer part so that the outer part entirely surrounds and is of the same length as the said inner part and is such as to form thereby pressure reduction conduits providing a tortuous pathway for liquid between for each pressure reduction conduit an inlet from within the tube to each respective pressure reduction conduit and an outlet between each respective pressure reduction conduit and an outer side of the said outer part.

It is implicit that there are means to effect an aperture through the inner part of the tube which will connect from an inner side of the tube to the pressure reduction channel, and there are means to effect an outlet through the outer part of the outer tube.

It is assumed that such co-extruded tubes can be caused to meld together to form an integral tube or it can be assumed that the two tubes to not meld together the one draws tightly around the other so as to at least provide for a sealing engagement over the formed channels.

In relation to the method of forming of channel shapes in the outer surface of the inner part of the tube it has been discovered that there is very significant difficulty in providing a shape which firstly in an economic way can be impressed into the outer surface of such tube and be kept there while the plastic is in essentially a molten state with out unduly deforming the remaining part of the tube during such impression.

It will be understood by those familiar with this art, that if the plastic being impressed is not at or above its melt temperature, then any resulting deformation may not be permanent within the shape.

This is achieved by providing for internal reaction pressure within the tube during the impression step at an impression station which will thereby support the tube while an impression is forced into the almost fluid plastics material.

Such an inner reaction pressure can be achieved in various ways, but in one preferred arrangement is provided by an internal mandrel which in

preference can be caused to travel with the tube while the impression is being caused.

One of the further difficulties relates to effecting an impression in such a way that a large number of these can be achieved around the outer perimeter of the inner tube.

This is in fact achieved by providing in one instance six dies which are independently moveable in a radial direction, each having a shape so that they can slide one with respect to the other so that alternate dies can be moved into an impressive position with a first action and the remaining dies can then be moved into an impressive position with a second action.

This is achieved by providing an appropriately complementary shape between adjacent surfaces of the dies.

There still remains the problem of ensuring sufficiently accurate forming of the plastic and impression die and to this end it has been found advantageous to provide that the dies provide not only a shaping by impression pressure but that there is also provided for suction to suck parts of the plastic into the less full parts of the die shape.

Such features assist in providing for best angular confirmation of the tortuous channel shape.

These features together with a number of other features will be better understood where the invention is described with reference to preferred embodiments which will now be described with the assistance of drawings in which:

Fig. 1 is a perspective view of a part of the drip irrigation tube made according to the embodiment with however an outer part being partly cut away showing the impressed shape within the outer surface of the inner part

Fig. 2 shows the tortuous path pressure reduction shape showing a first long part showing a principal direction channel path and then a second long part showing a return channel path in an opposite direction in each case parallel however to a center axis axis of the tube,

Fig. 3 is the same view as in Fig. 2 except that it shows an inlet part for an aperture through the inner part of the tube,

Fig. 4 is the same view as in Figs. 2 and 3 except it shows a last channel connecting through to an encircling outlet channel,

Fig. 5 is an enlarged perspective view of the tube as in each of the preceding drawings with partly cut away portions of the part at the left hand end of Fig. 3,

Fig. 6 is a cross sectional view through the tube showing the circumferential distribution of the channels as shown in Figs. 2, 3, and 4,

Fig. 7 is a lateral cross section of the tube as shown in Figs. 1, 5 and 6,

Fig. 8 is a schematic view in side elevation of a machine assembly effecting manufacture of a tube according to this embodiment,

Fig. 9 is an end view of the impressing dies with externally controlling pistons,

Fig. 10 is a side view of the impressing dies as in Fig. 9,

Fig. 11 is a cross section enlargement of the impressing dies as shown in the centre of Fig. 9 showing in particular the interlocking relationship of the respective dies,

Fig. 12 is a schematic side elevation in cross section of that part of the manufacturing device with a flying central mandrel,

Fig. 13 is the cross section A-A as shown in Fig. 12,

Fig. 14 is the cross section B-B as shown in Fig. 12,

Fig. 15 is the cross sectional view C-C as shown in Fig. 12 and

Fig. 16 is the cross sectional view D-D as shown in Fig. 15.

Referring in detail to the drawings and particularly Figs. 9,10 and 11 there are a plurality of channel forming segment die mount blocks 1 which are controlled in position by segment insert/retract pneumatic cylinders 2

There are segment bridging pneumatic cylinders 3, vacuum ports 4 and then constant temperature oil inlets 5 and constant temperature oil outlets 6.

There is a restricted passage entry puncturing pneumatic cylinder 7, channel forming die segments 8 and supporting core segments 9

A mandrel 10 which is located by being secured to a stem 11 extending from an extrusion die provides support for a tapered sleeve 12.

The tapered sleeve 12 is arranged so that with the clamping pressure exerted by pattern forming segments 8, this will cause the mandrel 10 to be moved in the direction of the channel forming die segments 8 to travel until released and there will be caused then a reaction from segment retaining springs 13 and there is provided a return pressure by reason of hydraulic piston and cylinder 14.

The pipe being impressed is shown at 25.

The interacting relationship of the impression forming dies specifically the pattern forming die segments 8 and the pattern forming die segment mount blocks 1 have a relationship so that when an impression action is anticipated, the segment insert, retract pneumatic cylinders 2 are synchronized so that in the first instance 8b, 8d and 8f are pushed into an impressing position and thereafter 8a, 8c and 8e follow.

When retracting, the same synchronized reaction arrangement is effected at 8e, 8c and 8a being first pulled out and then followed by 8b, 8d and 8f.

This is achievable because of the inter-relating shapes as shown particularly in Fig. 11.

Referring to the product thus formed this is shown more particularly in Figs. 1, 2, 3, 4, 5, 6 and 7.

To this end the tube arrangement at 15 includes an outer part and an inner part which in this instance are shown as being essentially integral in that by being co-extruded they are melded so as to be indistinguishable apart from microscopic examination which would show that the polymers of the outer part are crossing in direction as compared to those of the inner part.

The tube is manufactured from an appropriate plastic such as polythene and there is impressed into the outer surface of the inner part of the tube 15 a plurality of pressure reduction conduits 17 which are connected from an inlet 16 to an outlet 27.

Each of these conduits 17 are formed by having the channel shape as shown impressed into the outer surface of the inner part and being formed into a plurality of long parts each of which have a predominant direction extending longitudinally with the central axial direction of the tube 15.

There is then in each of long parts of the channel shapes 17 a general direction which is parallel to this axis and each of these are adjacent one and the other so that there can be readily formed between them either bridging channels shown typically at 24

The actual passage connections arrangement is shown particularly in the Figs. 2, 3 and 4 in which at the end of the last of the long parts there is shown an interconnecting passage 20 to a common circumferential passage 21 which in turn is connected to outlet circumferential passageway 23.

More particularly it is to be noted that the passageways have a large number of very abrupt changes in direction whereby water expected to pass therethrough will be caused to turn in most cases through approximately 90 degrees change in direction. This concept is not of itself new but is known in the art to provide pressure reduction substantially kinetic energy losses rather than friction losses in water .

The apparatus for manufacture of the tube is shown in schematic layout in Fig. 8 and provides in the first instance an extruder for the first inner part of

the tube shown at 30 which then leads through an assembly of 31 which includes the channel forming die segment mount blocks 1 located on a flying support assembly, the two positions being shown in the drawing, one of which is in dotted outline at the end of the pressure cycle.

The co-extruder extruding the outer part of the tube 39 is shown at 32 and this is then passed through a cooling chamber 33, a haul off device 34, an outlet aperture cutter 35 and a wind-off spool 36.

The assembly at 31 includes a large rotating cam wheel 37 having constant back pressure from a piston 38. The cam wheel 37 is profiled such that the forward velocity resulting from its action is constant therefore ensuring that the forming head assembly 31 will match the speed of the extruding inner port 38 of the tube 39.

Within the assembly of 31 there is an arrangement (not shown) to inject nitrogen internally into the supply conduit through the restricted passage entry opening which is formed during the impression step by the puncturing pneumatic cylinders 7.

1. A drip irrigation tube arrangement of plastics material where the tube is comprised of an inner part and an outer part, in which the outer part entirely surrounds the inner part and in which the inner part and the outer part are of substantially the same length, the arrangement being characterised in that there is formed so as to extend into an outer surface of the inner part, a plurality of channel shapes which are closed over by the outer part to form thereby pressure reduction conduits providing a tortuous pathway for liquid between for each pressure reduction conduit an inlet from within the tube to each respective pressure reduction conduit and an outlet between each respective pressure reduction conduit and an outer side of the said outer part.

2. A drip irrigation tube arrangement as in claim 1 further characterised in that the tortuous pathway is such as to cause pressure loss substantially by reason of kinetic losses.to water flowing therethrough.

3. A drip irrigation tube arrangement as in either of the two preceding claims further characterised in that the channel shapes are impressed into the outer surface of the inner part.

4. A drip irrigation tube arrangement as in any one of the preceding claims further characterised in that the outer part is formed around the inner part as a coextrusion of plastics materials.

5. A drip irrigation tube arrangement as in any one of preceding claims 1,2, or 3 further characterised in that the outer part is formed around the inner part as a separately formed conduit.

6. A drip irrigation tube arrangement as in any one of the preceding claims further characterised in that each tortuous channel is formed as at least one long part which has a predominant direction extending substantially parallel to a center axis of the tube.

7. A drip irrigation tube arrangement as in any one of the preceding claims further characterised in that each tortuous channel is formed as at least two long parts each of which has a predominant direction extending

substantially parallel to a center axis of the tube and each being located adjacent each other around the outer surface of the inner part.

8. A drip irrigation tube arrangement as in the last preceding claim further characterised in that each of the long parts is connected at one end to a channel commonly connecting other of the long parts to either an inlet os an outlet aperture.

9. A drip irrigation tube arrangement as in preceding claim 7 further characterised in that a first of the long parts is connected at a first end to an inlet aperture and at its opposite end to an adjacent end of a second of the long parts, the second of the long parts having its further end connected to an outlet or a further conduit connecting to the outlet .

10. A drip irrigation tube arrangement as in any one of the preceding claims further characterised in that each of the said long parts has a channel shape providing for passage of water therethrough in which the water will be caused to change direction through at least 90 degrees a substantial number of times.

11. A drip irrigation tube arrangement as in any one of the preceding claims further characterised in that there are a plurality of dies which are independently moveable in a radial direction, each having a shape so that they can slide one with respect to the other so that alternate dies can be moved into an impressing position with a first action and the remaining dies can then be moved into an impressing position with a second action.

12. A method of manufacture of a drip irrigation tube which comprises the steps of extruding as an inner part a first tube, impressing into an outer surface of such inner part at spaced apart locations along the said first tube a plurality of channel shapes providing for a tortuous pathway, and then closing over the said inner part including such channel shapes with an outer part so that the outer part entirely surrounds and is of the same length as the said inner part and is such as to form thereby pressure reduction conduits

providing a tortuous pathway for liquid between for each pressure reduction conduit an inlet from within the tube to each respective pressure reduction conduit and an outlet between each respective pressure reduction conduit and an outer side of the said outer part.

13. A method of manufacture of a drip irrigation tube as in the preceding claim 11 further characterised in that the closing over of the inner part is effected by passing the said inner part through a coextruder die and effecting an extrusion of the outer part around the said inner part as the said inner part passes through the said die.

14. A method of manufacture of a drip irrigation tube as in any one of the preceding method claims further characterised in that there is a set of dies located at a stamping station through which the inner part of the tube is adapted to extend subsequent to extrusion and there is caused at spaced apart intervals of time a forcing of the dies into the outer side of the inner part of the tube to impress the said channel shapes thereby at spaced apart locations along the length of the tube.

15. A method of manufacture of a drip irrigation tube as in any one of the preceding method claims further characterised in that there is a mandrel located within the extruding inner part of the tube positioned and adapted to provide a reaction support for the inner part at the stamping station and during the impression into the outer surface of the inner part of the channel shapes.

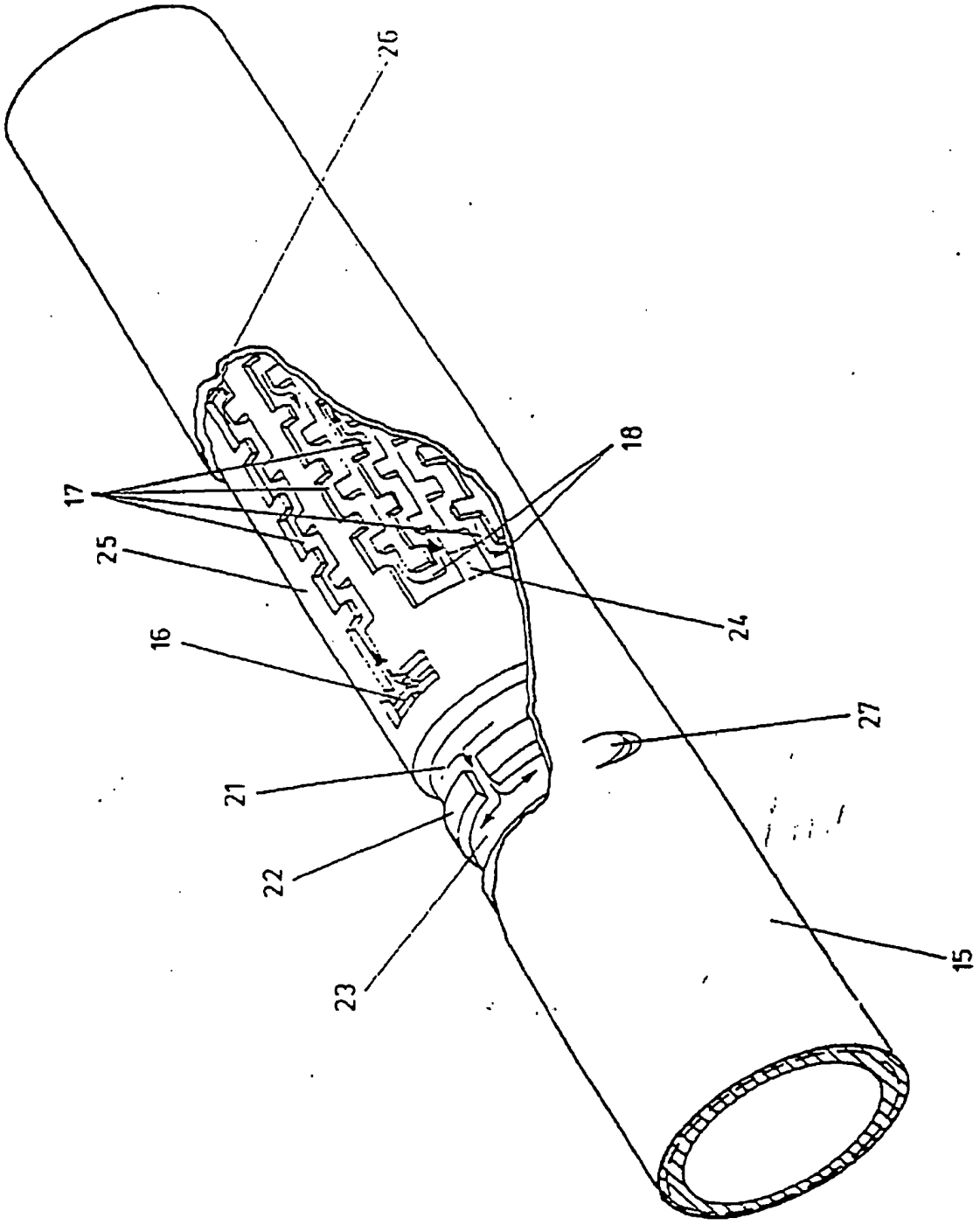
16. A method of manufacture of a drip irrigation tube as in the last preceding claim further characterised in that the mandrel is adapted to move with the extruding tube and the impressing dies during any impressing action of the dies.

17. A method of manufacture of a drip irrigation tube as in the preceding claim further characterised in that there are a plurality of dies which are independently moveable in a radial direction, each having a shape so that they can slide one with respect to the other so that alternate dies can be moved into an impressive position with a first action and the remaining dies can then be moved into an impressive position with a second action.

18. A drip irrigation tube arrangement substantially as described in the specification with reference to and as illustrated by the accompanying drawings.

19. A method of manufacture of a drip irrigation tube substantially as described in the specification with reference to and as illustrated by the accompanying drawings.

FIG 1



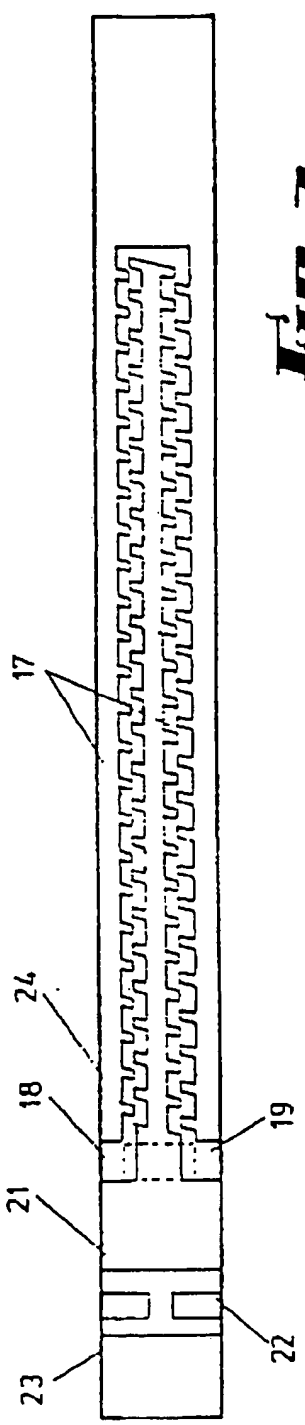


FIG 2

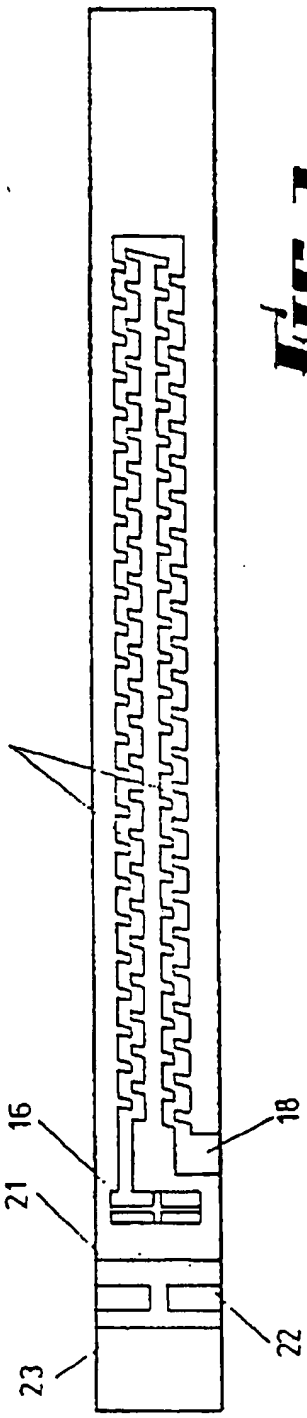


FIG 3

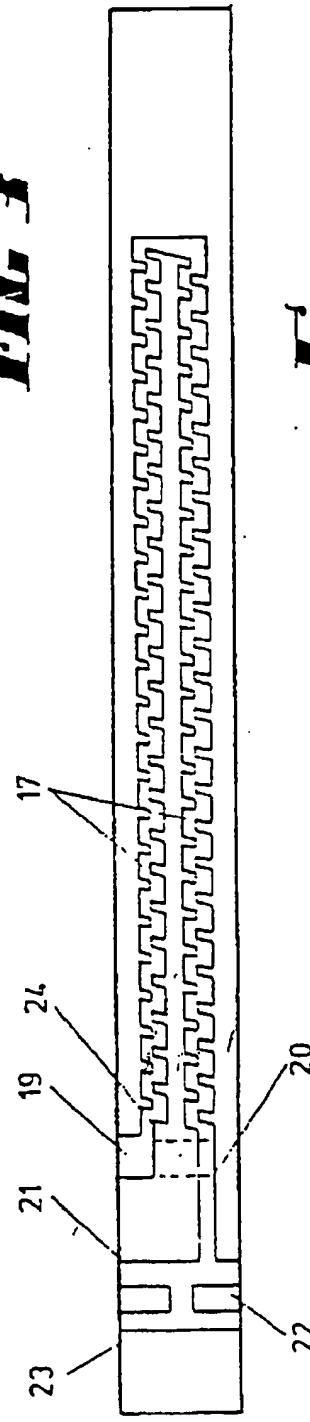


FIG 4

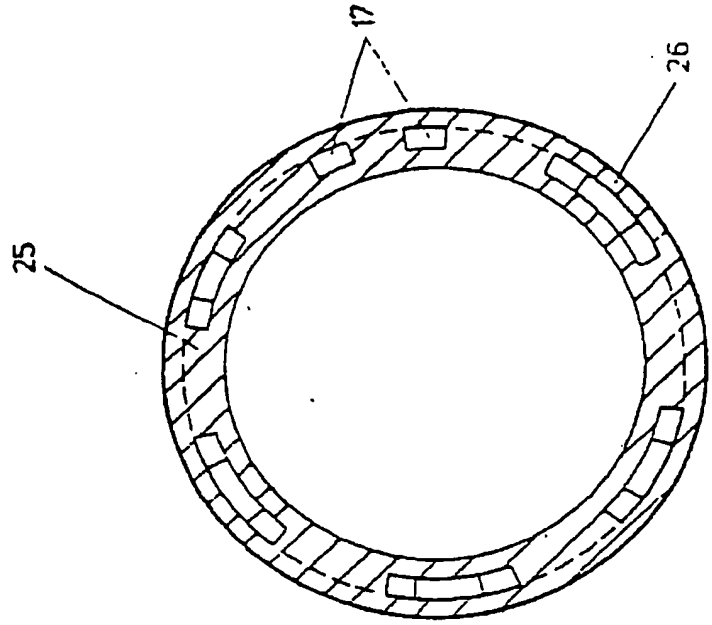


FIG 6

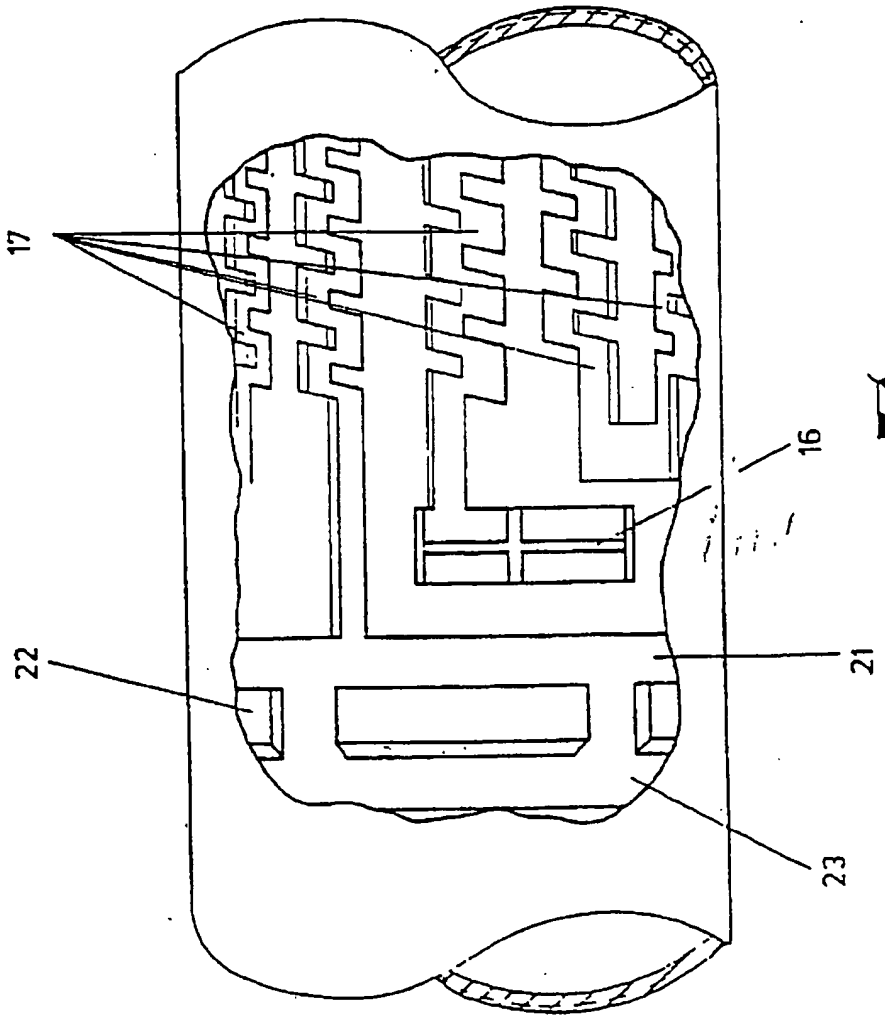


FIG 5

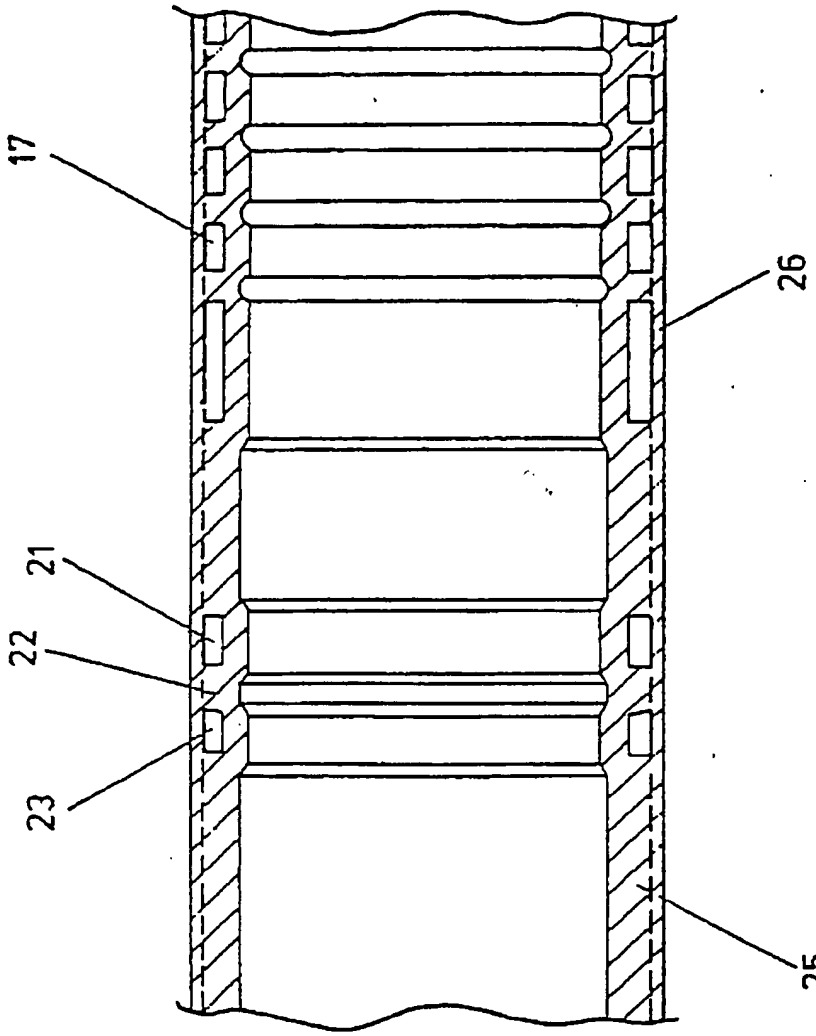
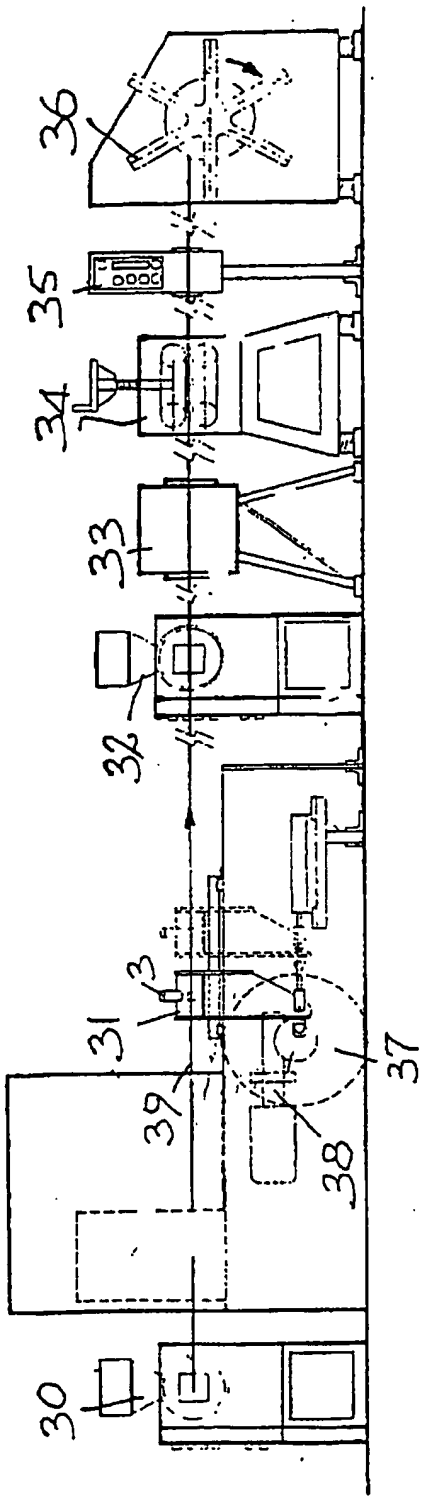


Fig 7

FIG 1



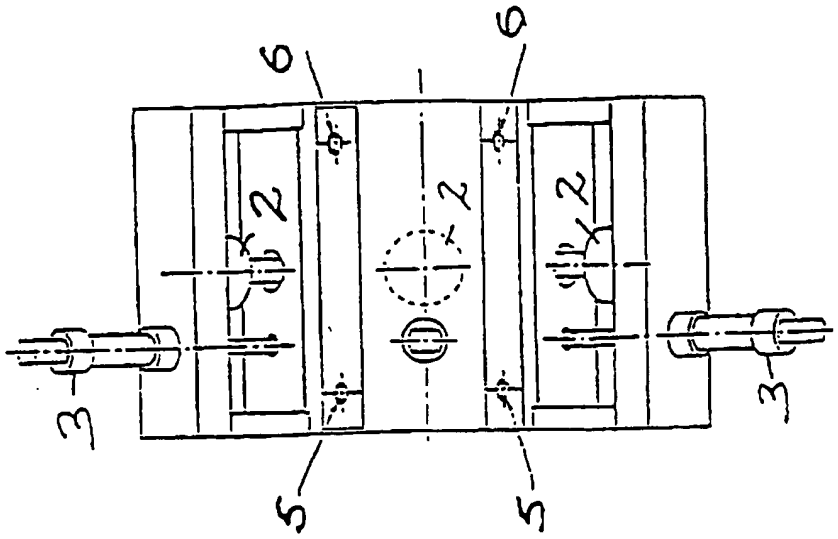


FIG 10

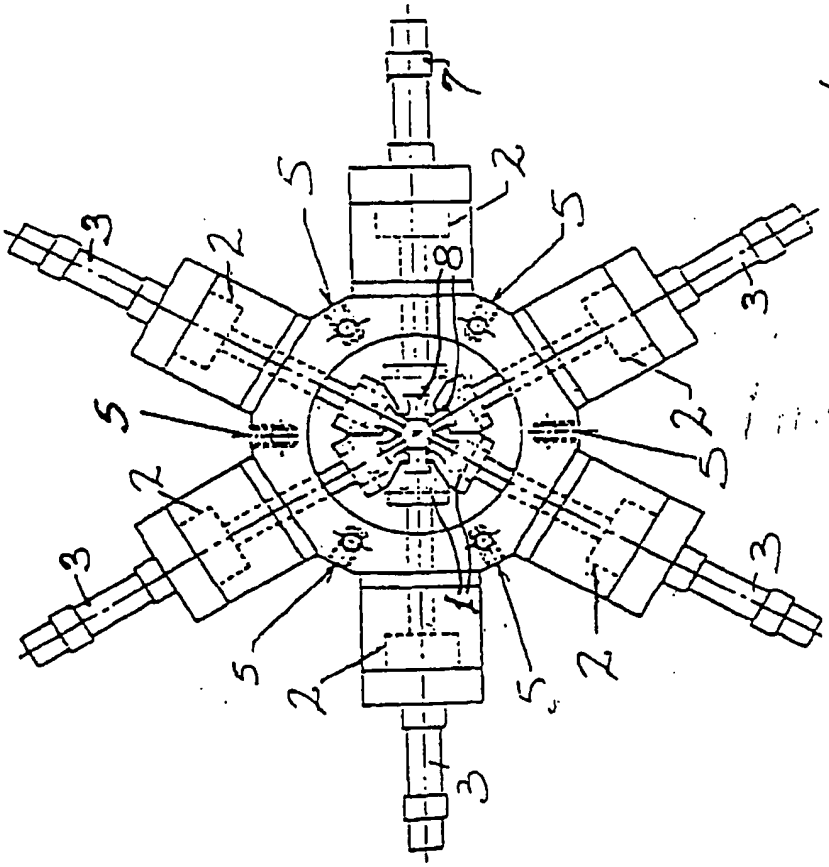
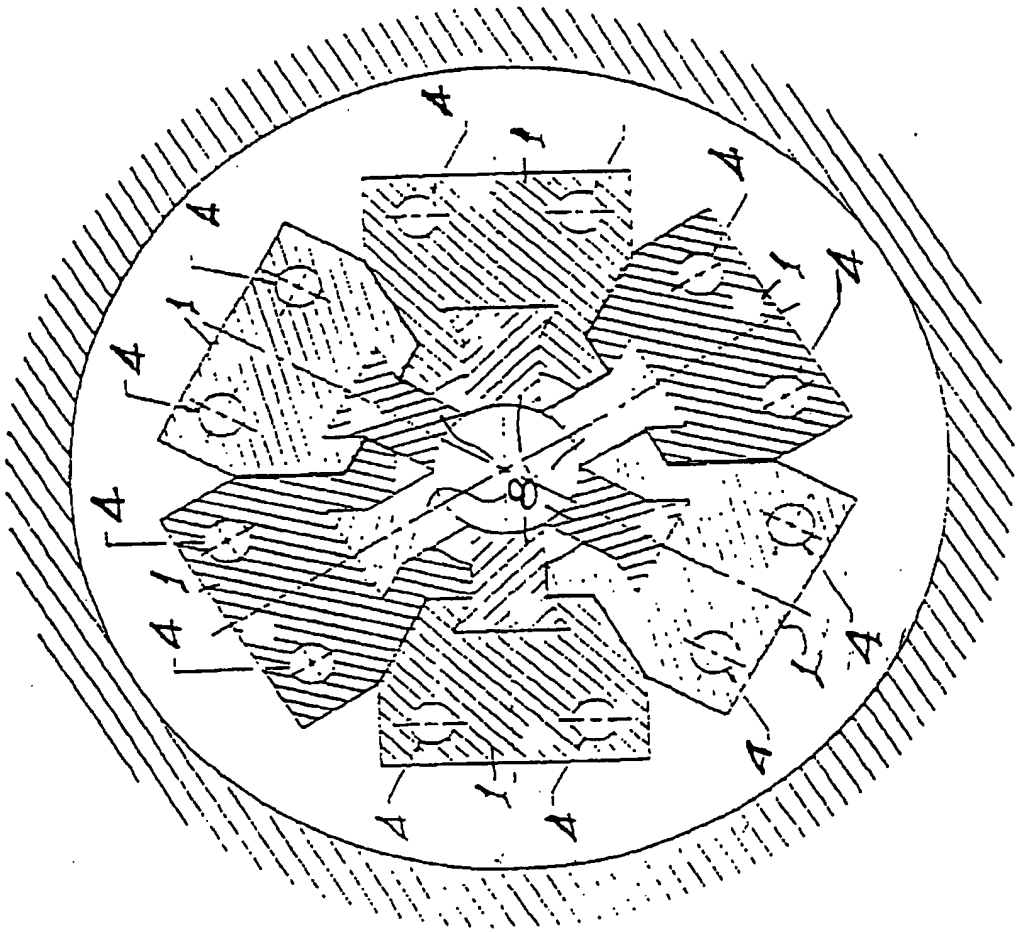


FIG 11

FIG 11



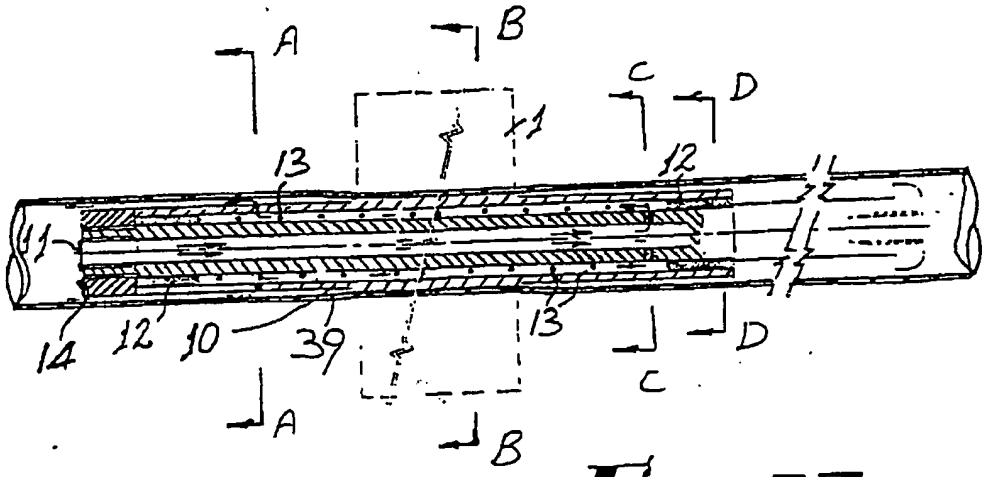


FIG 12

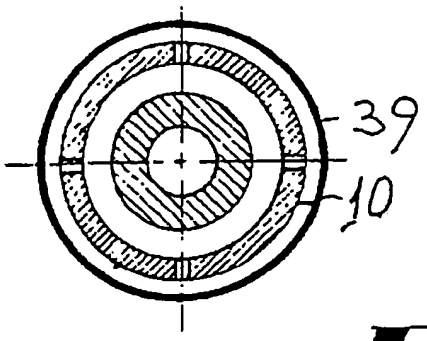


FIG 13

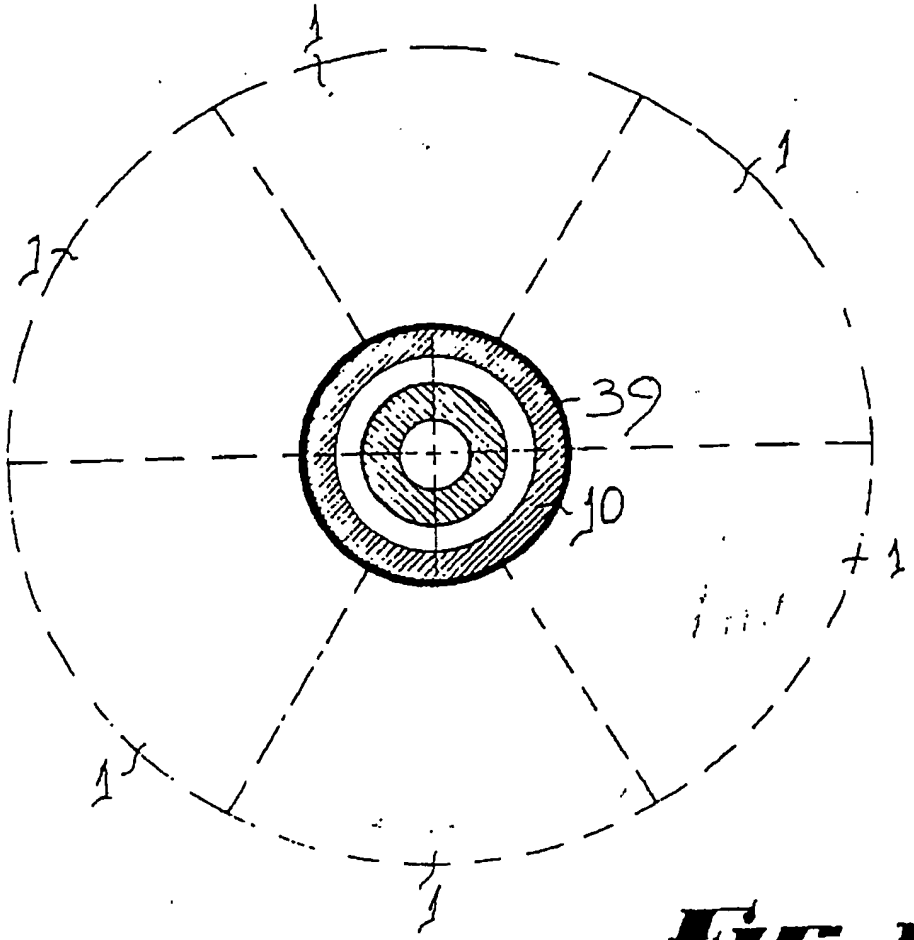


FIG 14

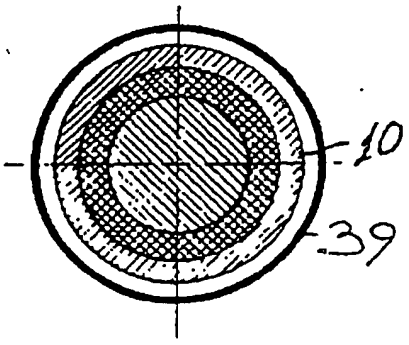


FIG 16

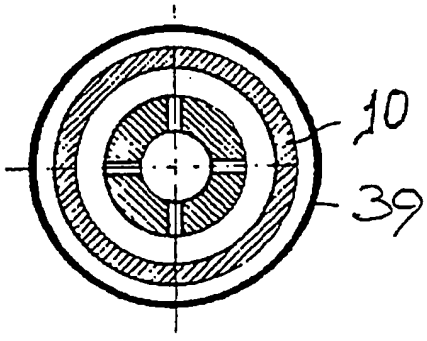


FIG 15

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 89/00160

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[4] A01G 25/16, B29C 69/00, B29D 23/22

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
I.P.C.	A01G 25/00, 25/16, B29D 23/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU: IPC as above and A01G 25/02, 25/06, B29C 47/06, 59/02, 69/00, B29D 23/04, 23/22, 24/00, B32B 1/08

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
A,Y	AU,B, 34146/68 (424908) (HEGLER) 4 September 1969 (04.09.69)	(12-14)
X	AU,B, 42360/72 (458219) (THE STANDARDS INSTITUTION OF ISRAEL AND GILAAD) 22 November 1973 (22.11.73)	(1-3, 5-10)
A	AU,B, 75565/74 (484446) (SAHAGUN-BARRAGAN) 20 May 1976 (20.05.76)	
A,Y	AU,B, 24160/77 (511876) (DROSSBACH) 19 October 1978 (19.10.78)	(12-14)
A	AU,B, 34599/78 (519503) (SAHAGUN-BARRAGAN) 4 October 1979 (04.10.79)	
A	AU,B, 33361/84 (579113) (TOWNSEND CONTROLS PTY. LTD.) 28 March 1985 (28.03.85)	
X,Y	AU,A, 43178/85 (SNELLING) 12 December 1985 (12.12.85)	(1-10, 12-14)
X,Y	CH,B, 655636 (I.P.E. INDUSTRIAL PLANNING & ENGINEERING ENTERPRISES LTD) 15 May 1986 (15.05.86)	(1-4, 12-14)

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
21 June 1989 (21.06.89)	3 July 1989
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	G.M. COX

Form PCT/ISA/210 (second sheet) (January 1985)